Section 7

ALI Focal Plane Technology

MIT-LL Subcontract No. BX-6283

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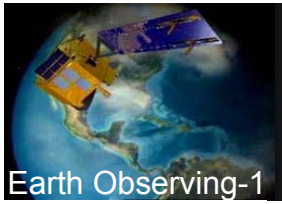
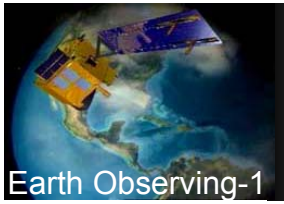


Raytheon Provided the ALI Focal Plane System (FPS)

- ***Combined Effort of Santa Barbara Remote Sensing (lead) and Raytheon Infrared Operations, Goleta, CA***
- ***FPS was designed and developed from June 1996 to June 1998***
- ***FPS was delivered to MIT-LL on June 18th, 1998***



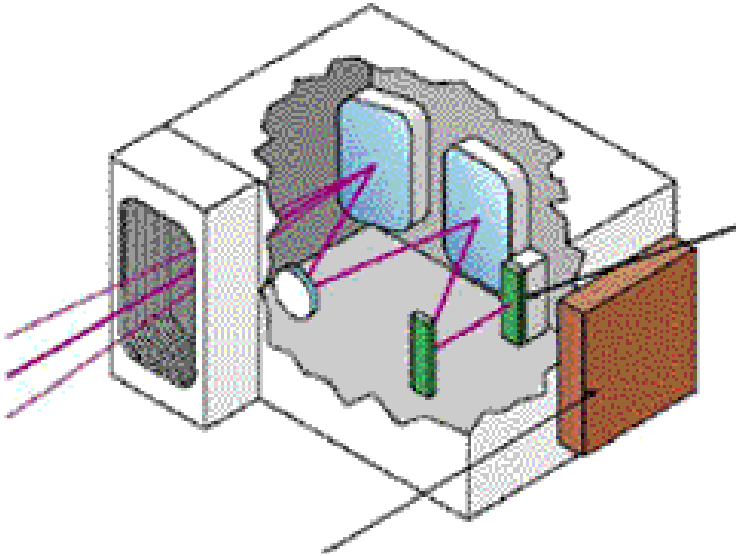
Raytheon's ALI Focal Plane System

Technologies Advanced in Maturity to Benefit Future Science Missions with Reduced Risk

- ***Advanced 2nd-generation CMOS readout ICs***
- ***Small (13.2X13.2 µm and 40X40 µm) pixels, high-density Sensor Chip Assemblies (SCAs)***
- ***Monolithic Si VNIR detector elements***
- ***High operating temperature (220 K) SWIR (2.5 µm wavelength cutoff) HgCdTe detector arrays***
- ***High-density edge-bonded MS/PAN filter assemblies***

Focal Plane System in ALI

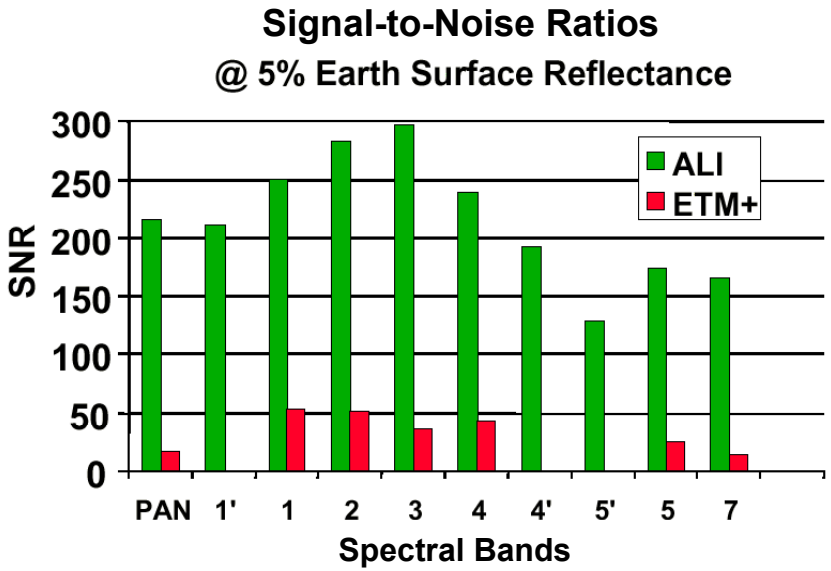
- ***Focal Plane System Elements***
  - ***Focal Plane Assembly***
  - ***Focal Plane Electronics***



Focal Plane Electronics (FPE)

Focal Plane Assembly (FPA)

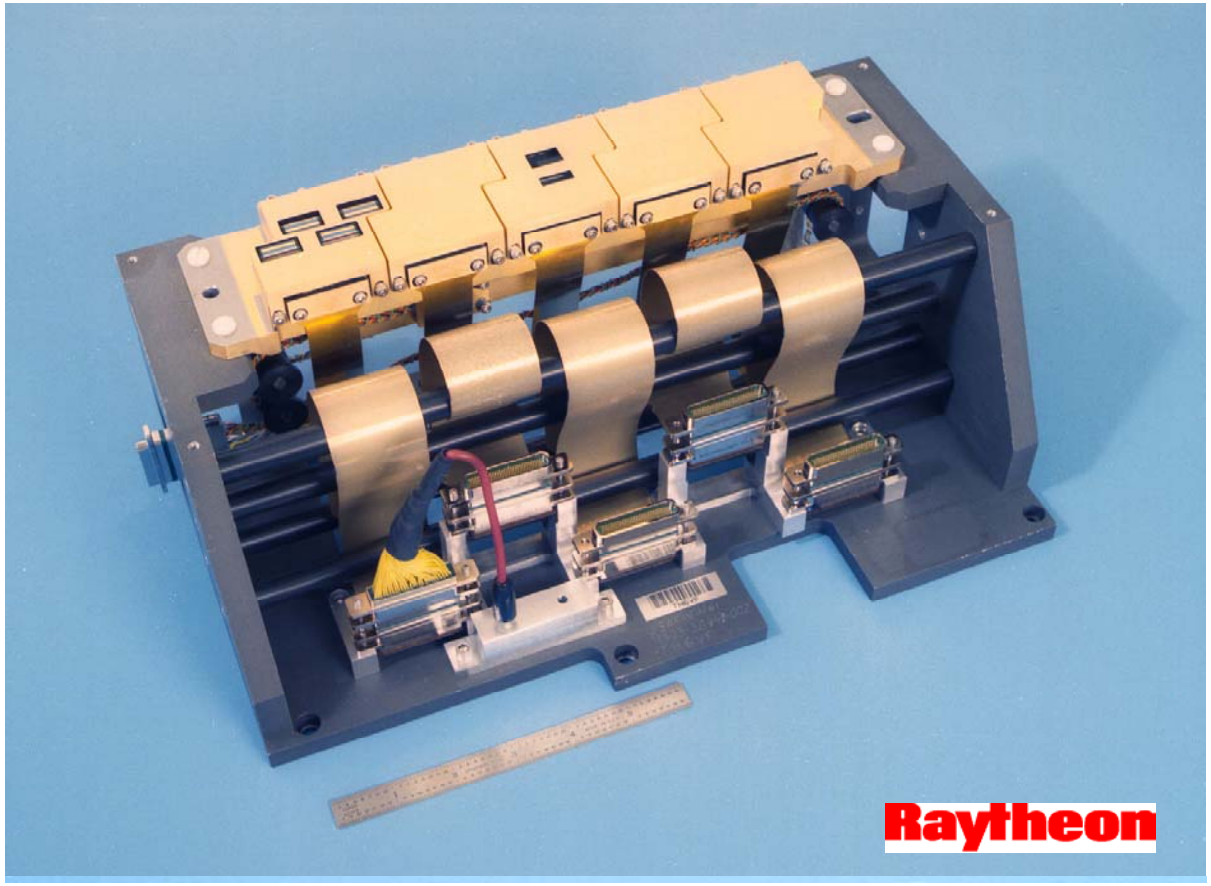
ALI FPS Demonstrates ~5 X Performance Improvement Over Landsat 7



Band	Wavelength (mm)	Detector Type	GSD (m)	# Detectors
Pan	0.480-0.680	SiPhotodiode	10	3840
MS-1'	0.433-0.453	SiPhotodiode	30	1280 Per Band
MS-1'	0.450-0.515			
MS-2	0.525-0.605			
MS-3	0.630-0.690			
MS-4	0.775-0.805			
MS-4'	0.845-0.890			
MS-5'	1.200-1.300	PV HgCdTe	30	1280 Per Band
MS-5'	1.550-1.750			
MS-7	2.080-2.350			

- *FPA operates at the "warm" temperature of 220 K*
- *Nominal sample rates:*
  - *226 Hz (VNIR, SWIR)*
  - *678 Hz (PAN)*
- *4,096 selectable sample rates (to accommodate for altitude variation)*
- *Adjustable integration duty cycle (to accommodate scene level)*
- *SNRs shown (see bar chart) acquired at 5 % of maximum scene irradiance*
- *Standard Landsat bands (PAN, 1, 2, 3, 4, 5, 7) and experimental bands (1', 4', 5') support both L7 comparison and new science*

Multispectral/Panchromatic VIS-SWIR FPA

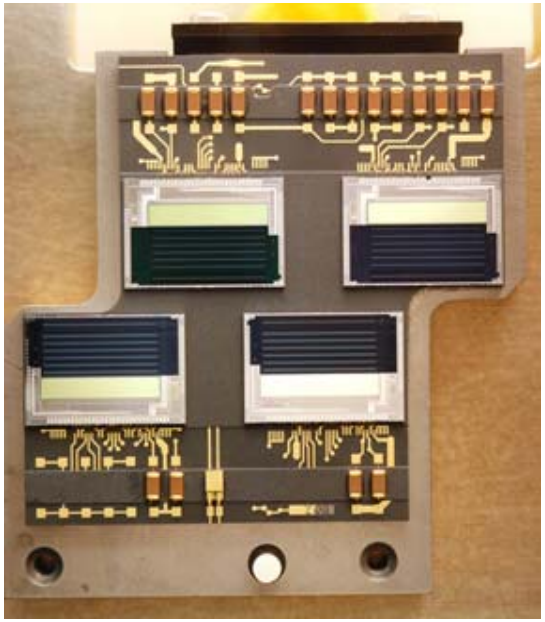


Main Focal Plane Assembly in Handling Fixture

- ***FPS performance exceeded both program specs and prior LANDSAT performance levels***
- ***FPA designed to support five (5) MS/PAN modules for future Landsat missions (15° swath coverage)***
- ***Demo program called for partially-populated FPA, one module with detectors***
- ***Integrated with flight telescope at MIT-LL in Summer 1998***

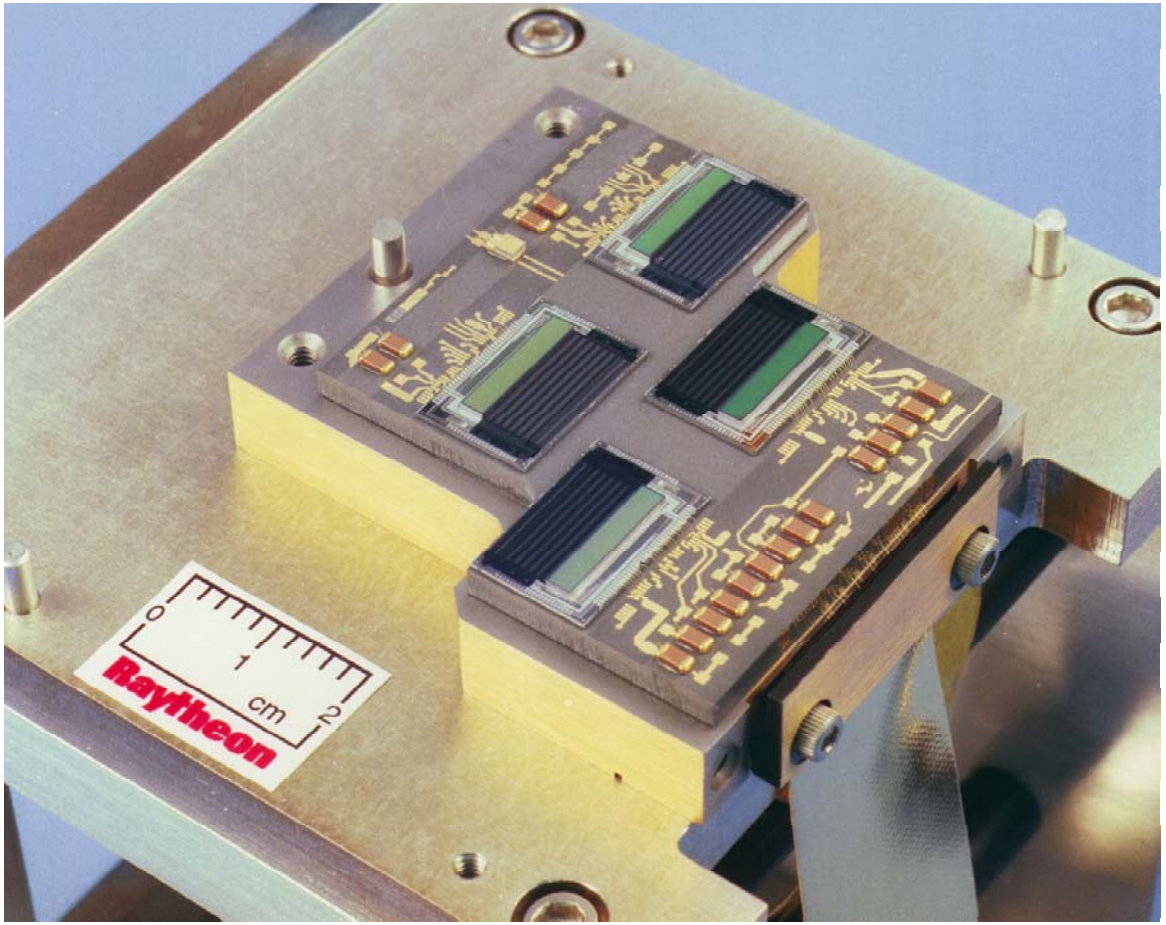
MS/PAN Module Meets or Exceeds all Specifications

- ***Responsitivities optimized for each band to satisfy flux range requirements***
- ***SNR meets program specs with an average of 50 % performance margin!***
- ***99.94 % measured operability meets spec with dramatic margin***
  - ***9 "inoperable" pixels***
  - ***15,360 total pixels on MS/PAN module***
- ***Excellent radiometric uniformity and sensitivity, even for high-resolution 13.2 µm x 13.2 µm panchromatic (PAN) pixels***
- ***High operating temperature (220 K)***
- ***Low power (~ 300 mW/module)***
- ***Stable response vs. temporal and thermal variation***



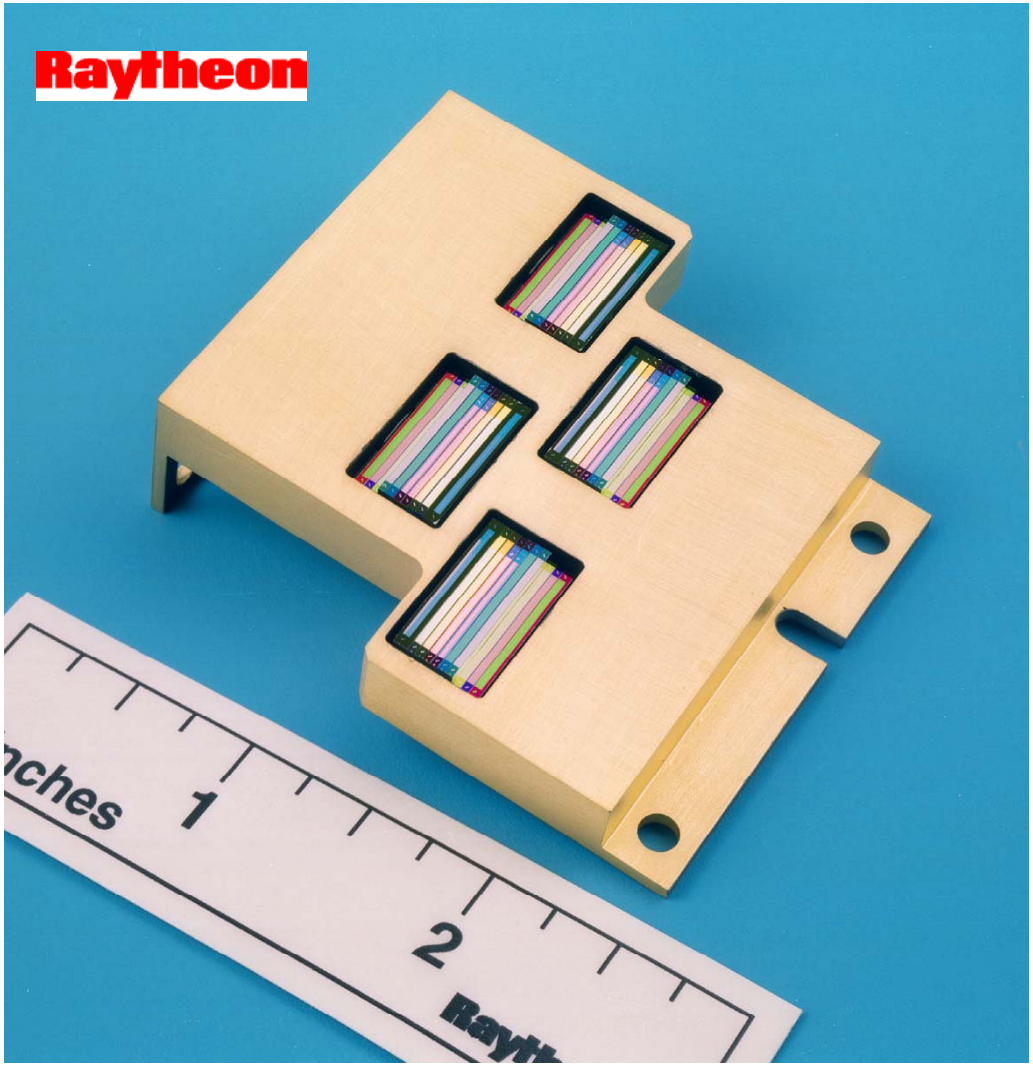
MS/PAN Module Subassembly

(shown with filter-bezel removed)



- ***Flight module shown mounted in assembly tooling fixture***
- ***4 SCAs per module***
- ***Multi-layer ceramic motherboard***
- ***Beryllium pedestal***
- ***16-inch cryo cable***
- ***18 bypass capacitors***
- ***1 temperature sensor***

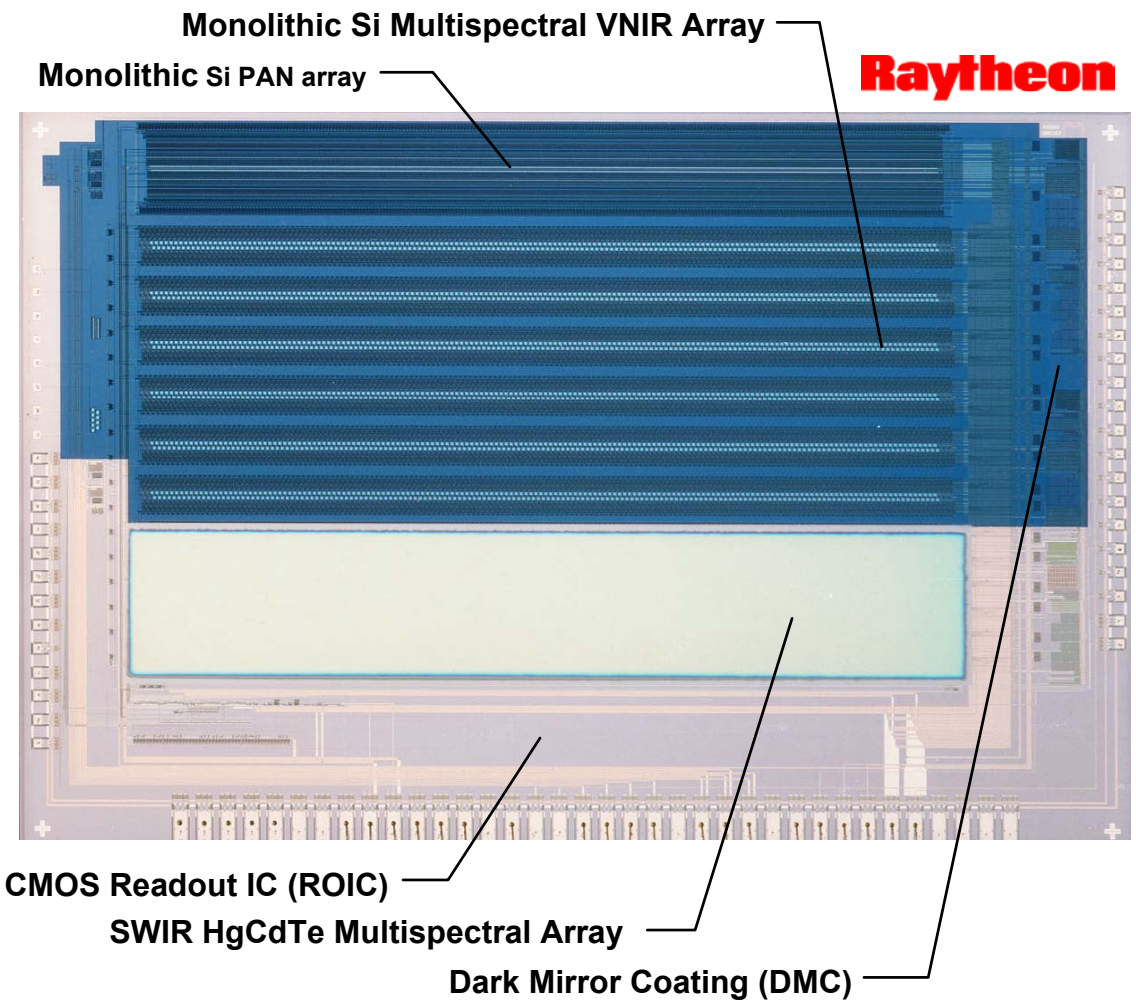
MS/PAN Spectral Filter-Bezel Assemblies



- ***Four filter assemblies per module (one per SCA)***
- ***10-piece edge-bonded, "butcher block" filter assemblies***
  - ***Dark Mirror Coating (DMC) defines clear apertures***
  - ***Edge coatings for optical baffling***
- ***Filter assemblies bezel-mounted as shown***
- ***Excellent transmission, spectral bandpass, and out-of-band rejection characteristics***

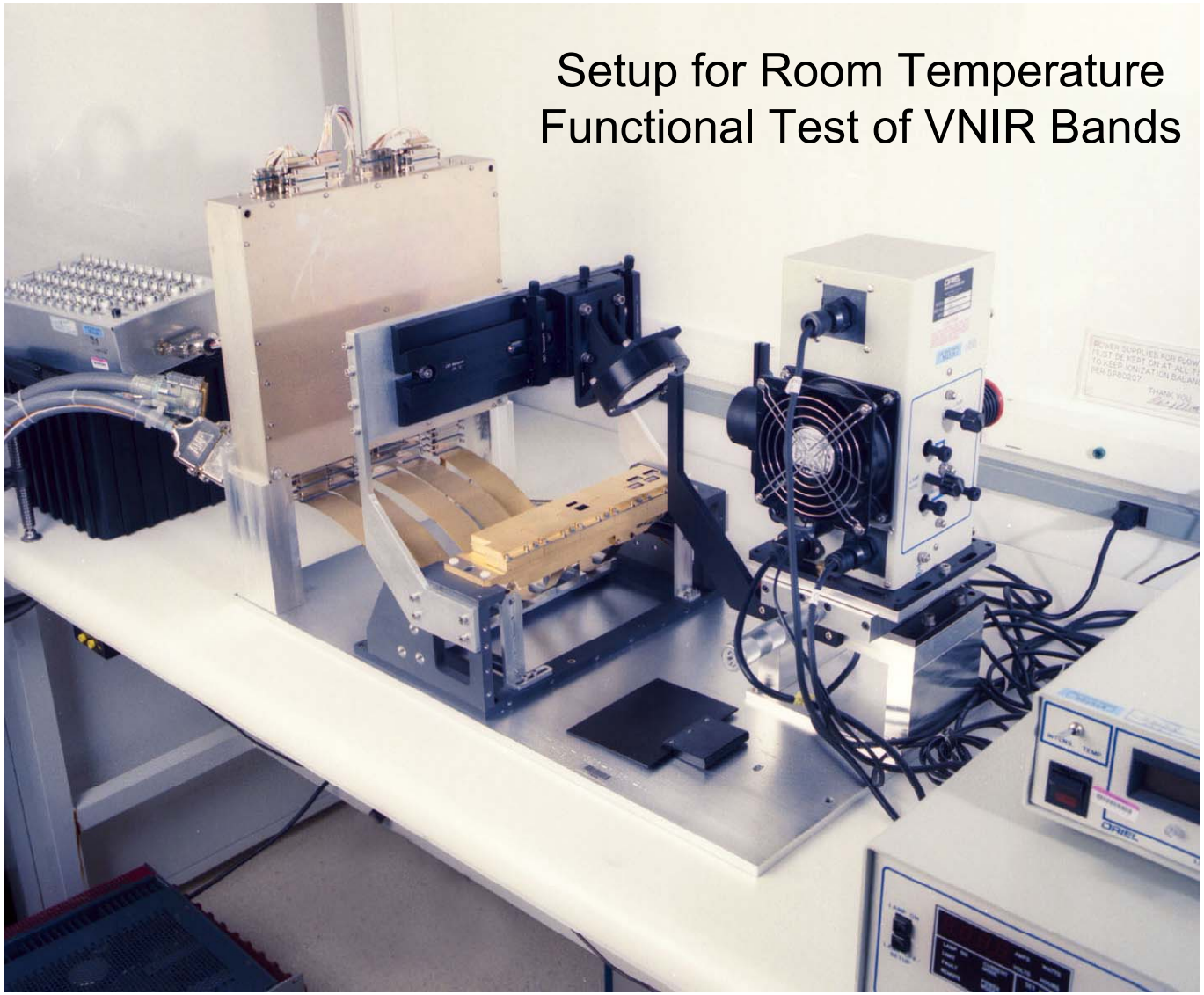
MS/PAN Sensor Chip Assembly (SCA)

- ***Spectral Bands:***
  - *Panchromatic (PAN)*
  - *1, 1', 2, 3, 4, 4' (VNIR)*
  - *5', 5, 7 (SWIR)*
- ***Array Configurations:***
  - *2 x 480 (PAN)*
  - *2 x 160 (VNIR, SWIR)*
- ***Pixel Dimensions:***
  - *(13.2 x 13.2) µm (PAN)*
  - *(39.6 x 40.0) µm (VNIR, SWIR)*
- ***CMOS CTIA ROIC***
  - *(Orbit 1.2 µm, rad-tol. process)*
- ***Detector Materials:***
  - *Monolithic Si (PAN, VNIR)*
  - *SWIR HgCdTe (SWIR)*
- ***Monolithic Si Detectors***
  - *Built directly into ROIC*
  - *optically delineated with metal and DMC*
- ***SWIR HgCdTe Detector Array***
  - *2.5 µm cutoff wavelength*
  - *Fully-redundant detector select*

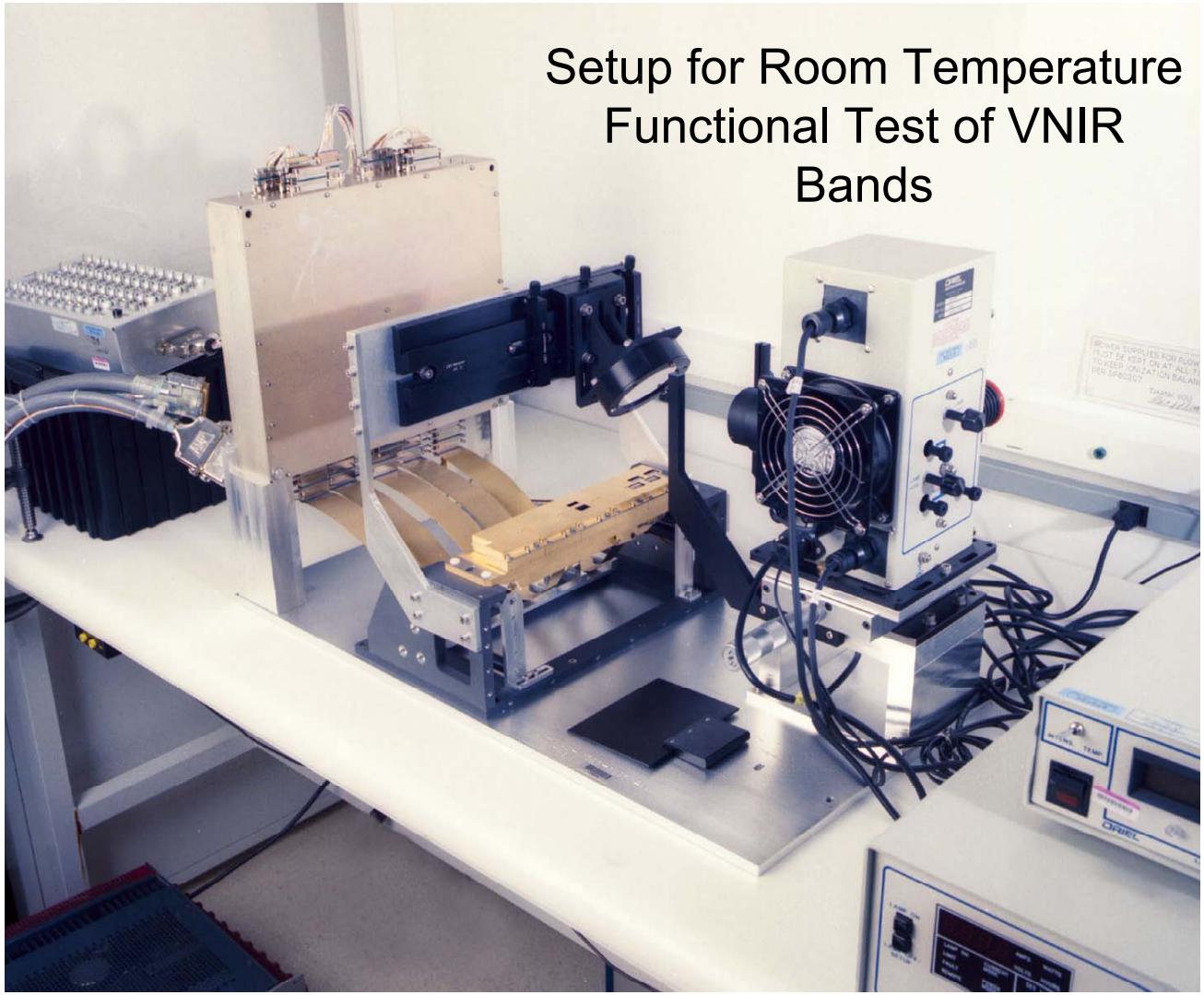


Raytheon

FPS Delivered with Ground Support Equipment



FPS Delivered with Ground Support Equipment



ALI FPA Fully Populated for Future Landsat Mission

- ***Populate Focal Plane with Five MS-PAN Modules***
  - ***Full 185 km wide field-of-view***
  - ***Main focal plane bench designed for five modules***

- ***Changes required to accommodate full 185 km MS-PAN coverage***

Resource	*ALI*	*Advanced Landsat*
Data Ports	1	5
Data Rate	102.4 Mb/sec	512 Mb/sec
FPE Power	~15 Watts	~50 Watts
FPA Size	30.7 X 6.6 X 5.2 cm	30.7 X 6.6 X 5.2 cm